# Spatial Variability and Robust Interpolation of Seafloor Sediment Properties Using the SEABED Data Bases

Chris Jenkins
INSTAAR, University of Colorado, Boulder 80309-0450, USA
phone: 1-303-735-5250 fax: TBA email: chris.jenkins@colorado.edu

N00014-05-1-0080

## LONG-TERM GOALS

The goal of this project is to build a method for making the best possible griddings of seafloor data, even for regions that have weak data coverage.

## OBJECTIVES

Gridded maps are the most sought-after type of information from seafloor properties databases, but computing them reliably is not straightforward.

The technical goal of the project is a gridding method that is mathematically rigorous and statistically reliable, robust under different qualities of input data, free of geometric artefacts, and acceptable on inspection to experts familiar with the terrain being mapped. We call this goal a Competent Interpolator (CI).

## APPROACH

The work is collaborative with John Goff of UTIG, Austin, Texas. It proceeds on 3 lines:

(i) investigating how variability of the seabed is distributed and may be dealt with apprporiately in mappings;

(ii) writing a practical, robust and competent interpolation program and releasing it publicly;

(iii) using that development with real datasets to encounter the problems common in existing interpolation techniques, and to find and test ideas for solutions and improvements;

(iv) describe the work in publications.

For this first year we adopted an underlying deterministic Inverse Distance Weighted (IDW) method. In the next we will implement a geostatistical variant.

## WORK COMPLETED

Variability was investigated using a variety of techniques, with results that are still being considered with a view to robust techniques.

| Report Documentation Page | Form Approved OMB No. 0704-0188 |
|---|---|



| | | |
|---|---|---|
| 1. REPORT DATE<br>**30 SEP 2005** | 2. REPORT TYPE | 3. DATES COVERED<br>**00-00-2005 to 00-00-2005** |
| 4. TITLE AND SUBTITLE<br>**Spatial Variability and Robust Interpolation of Seafloor Sediment Properties Using the SEABED Data Bases** | | 5a. CONTRACT NUMBER<br>5b. GRANT NUMBER<br>5c. PROGRAM ELEMENT NUMBER |
| 6. AUTHOR(S) | | 5d. PROJECT NUMBER<br>5e. TASK NUMBER<br>5f. WORK UNIT NUMBER |
| 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)<br>**University of Colorado,INSTAAR,Boulder,CO,80309** | | 8. PERFORMING ORGANIZATION REPORT NUMBER |
| 9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) | | 10. SPONSOR/MONITOR'S ACRONYM(S)<br>11. SPONSOR/MONITOR'S REPORT NUMBER(S) |
| 12. DISTRIBUTION/AVAILABILITY STATEMENT<br>**Approved for public release; distribution unlimited** | | |
| 13. SUPPLEMENTARY NOTES<br>**code 1 only** | | |
| 14. ABSTRACT | | |
| 15. SUBJECT TERMS | | |

| 16. SECURITY CLASSIFICATION OF: | | | 17. LIMITATION OF ABSTRACT | 18. NUMBER OF PAGES | 19a. NAME OF RESPONSIBLE PERSON |
|---|---|---|---|---|---|
| a. REPORT<br>**unclassified** | b. ABSTRACT<br>**unclassified** | c. THIS PAGE<br>**unclassified** | **Same as Report (SAR)** | **6** | |

A competent interpolator was built, and in the process the following issues were encountered and solutions to them implemented.

| Problem | Solution |
|---|---|
| a) Properties of deep-water sites are extended to shore wherever inshore data is scarce | Adaptive search radius, smaller as approaching shoreline |
| b) Loss of resolution when search radii are large, even in areas of high data detail | Nested median computing process for cells with data |
| c) Grid bears no relation to seafloor topography or environmental zonations (such as wave base); gridded results transgress coastal zones | Use an (IDW) weighting that depends on a geographic and water depth difference metric |
| d) Data to one side of the cell may dominate the result. For example the deeper-water samples commonly dominate the gridding of inshore areas. | Equalize the contributions of angular quadrants around the cell |
| e) Rock areas not properly represented by seabed-sampling datasets, especially inshore | Bring coastal classifications and regolith databases such as European Soils Database into the input data. |
| f) Displays of uncertainty do not accompany the gridding. | An uncertainty calculation is now included, involving the measurement, local variability, and spatial components of uncertainty. |

Menial but important software issues were also tackled, such as including spatial indexing of input data to give acceptable speed for dealing with >>10,000 data points.

**RESULTS**

The first year's CI is written, and with the exception of minor changes and improvements to documentation is ready to release. Measurements on the outputs indicate that the statistical reliability is as good as or slightly better than Ordinary Kriging and other high-performing methods.

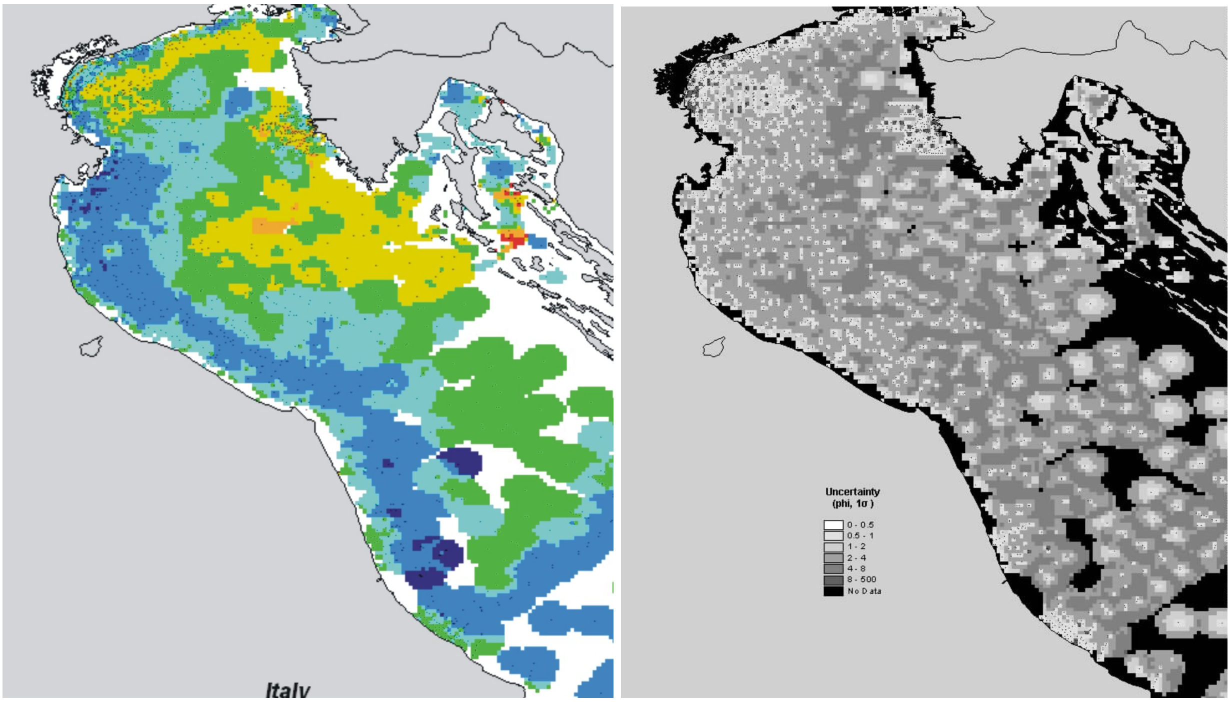


***Figure 1. Example of a competent interpolation of grain sizes in the Adriatic Sea. (A) Interpolated grain sizes, phi. (B) Uncertainties, phi at 1-sigma significance.***
***[A shows a geologic pattern of sediment types at the seabed. B shows haloes of increasing uncertainty around the data points, and areas of specially high or alternatively low uncertainty.]***
***The grids were computed using a 6 point, power 2 form of IDW with these measures for competence included: search radius adjusted by coastal proximity, geographic-water depth distance metric, output of uncertainties.***

Meanwhile, competency on the grids has been improved. Performance in this respect is more difficult to monitor than the statistical errors, but CI griddings for the Adriatic Sea, West Florida Shelf, Gulf of Carpentaria have been scrutinized through the year by experts and for specific modeling and analysis projects: sediment transport (R Signell, C. Sherwood, USGS, C. Harris UVA), shrimp habitats (P. Rubec Florida FWC), seabed forward modeling (C. Griffiths CSIRO). The gridded results also match more closely than by using other gridding packages, the minor morphology of the seabed, for instance relict sand banks of the northern Adriatic Sea. A number of visually detectable artifacts in standard types of griddings have been resolved.

In the course of the work we investigated the patterns of seabed variability in a number of locations, using semi-variogram statistical techniques. An example is an investigation of sediment character variances versus geographic distance and water depth differences (Fig. 2). This diagram is difficult to interpret, but laid the basis for creation of a higher-performance IDW distance metric in the CI.

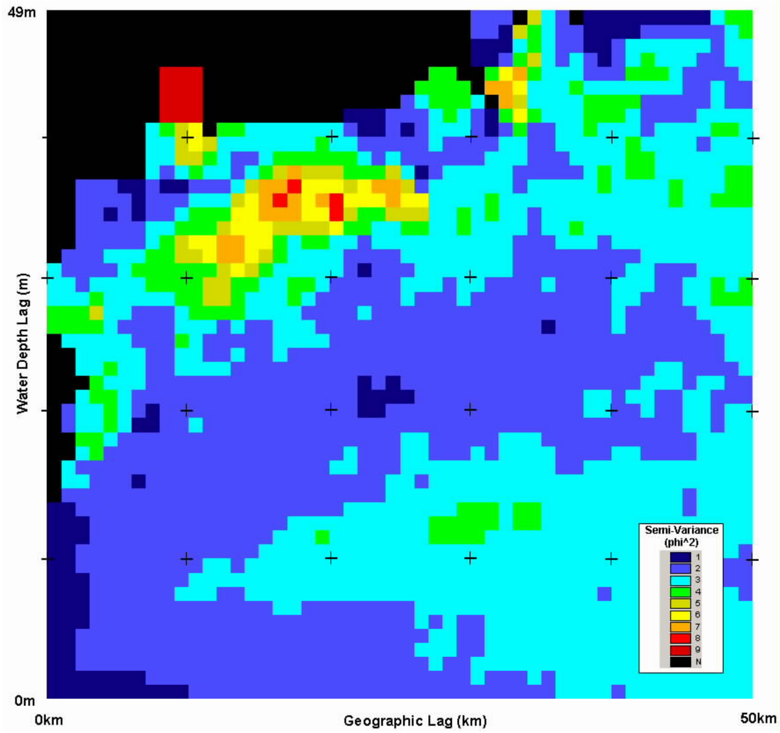


***Figure 2. A two-dimensional semivariogram on both geographic and water depth lags, constructed by John Goff, UTIG. A 1-dimensional semivariogram representing just geographic lags is the running average along the X-axis; for water depth lags the running average along Y-axis. [Shows from blue to red increasing variance of seabed character with increasing distance between the data points on the X-axis and increasing difference of depth along the Y-axis.] A climax in the variance lies at 20km distance and 35m depth difference.***

## IMPACT/APPLICATIONS

Given the high demand for gridded maps from seabed databases like dbSEABED, this project could have a significant impact on the reliability of inputs to coastal and sediment transport models, global change models, habitat mapping and analysis, and acoustic propagation studies.

## TRANSITIONS

Throughout the work we have had close cooperation with the US Geologcal Survey (USGS; Coastal Marine Geology Group Woods Hole, St Petersburg and Santa Cruz), Forschungsanstalt der Bundeswehr fuer Wasserschall und Geophysik (FWG; Kiel, Germany), and various users of the grids as mentioned above. One goal is to make the interpolator standard within dbSEABED, but a version will be released open source by INSTAAR for others to consider using on other datasets, using a web public facility.

## RELATED PROJECTS

John Goff (UTIG, Austin) collaborator, is investigating geostatistical noise-suppression and interpolation using the data and ideas of this program. Cedric Griffiths of CSIRO (Perth Australi) is applying gridded results to forward modeling of the seabed with consequences for the insurance and maintenance of subsea pipelines, etc. The German Navy is assessing methods of bringing the grids into Electronic Charting Display and Information Systems (ECDIS). In the future, the dbSEABED project will use the CI routinely for many appplications.

## PUBLICATIONS

Goff, J.A., Mayer, L., Schwab, W., Traykovski, P., Wilkins, P., Jenkins, C., Kraft, B., Evans, R. and Buynevich, I. 2005. Detailed investigations of sorted bedforms, or 'rippled scour depressions' within the Martha's Vineyard Coastal Observatory, Massachusetts. *Contl Shelf Res*. 209, 147-172.

Li, F., Dyt, C., Griffiths, C.M., Jenkins, C., Rutherford M. and Chittleborough, J. 2005. Seabed Sediment Transport and Offshore Pipeline Risks in the Australian Southeast. APPEA Jl, 2005.